Report 11643
15 March 2000

AEROJET

Integrated Advanced Microwave Sounding Unit-A (AMSU-A)

Engineering Test Report

AMSU-A1 S/N 108 Disturbance Torque and Angular

Momentum Measurements

Contract No. NAS 5-32314
CDRL 207

Submitted to:

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Submitted by:

Aerojet
1100 West Hollyvale Street
Azusa, California 91702

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TO: J. Linn

FROM: R. Bahng

SUBJECT: AMSU-A1 S/N 108 Disturbance Torque and Angular Momentum Measurements.

COPIES TO: J. Christman, A. Nieto, P. Patel, J. Pieper, R. Platt, D. Tran, Electronic File

REFERENCES:

1. IS-2617547, Unique Instrument Interface Specification for the Advanced Microwave Sounding Unit-A1 (AMSU-A1), RCA Corporation Astro-Electronics.
2. S-480-79, Performance Assurance Requirements for the EOS/METSAT Integrated Programs, Goddard Space Flight Center.
3. S-480-80, Performance and Operation Specification for the EOS/METSAT Integrated Programs, Goddard Space Flight Center.
4. AE-26151/12, Process Specification: Momentum Compensation and Uncompensation Test Procedure for the AMSU-A System, GenCorp Aerojet Azusa, July 8, 1998.
5. OC-462 Rev. 4, Advanced Microwave Sounding Unit (AMSU-A) Momentum Compensation Test Procedure, GenCorp Aerojet Azusa.
6. Shop Order 796019, Momentum Compensation Test Procedure for METSAT AMSU-A1 S/N 108, P/N 1331720-2-MOM, GenCorp Aerojet Azusa.
7. Drawing No. 1333964, AMSU-A1 Thermal Interface Control and Instrument Configuration Drawing, GenCorp Aerojet Azusa.
8. Matra Marconi Space Memorandum MO.NT.MMT.SY.0088, Analysis of Microdynamics Characterisation of AMSU-A1 and AMSU-A2, June 28, 1999.
9. Aerojet Interoffice Memorandum 98#181, "METSAT AMSU-A1 S/N 105 Disturbance Torque and Momentum Measurements," R. Bahng to L. Paliwoda, March 30, 1999.
10. Aerojet Interoffice Memorandum 98#335, "METSAT AMSU-A1 S/N 106 Disturbance Torque and Momentum Measurements," R. Bahng to L. Paliwoda, June 30, 1999.
11. Aerojet Interoffice Memorandum 98#513, "METSAT AMSU-A1 S/N 107 Disturbance Torque and Momentum Measurements," R. Bahng to L. Paliwoda, October 11, 1999.

PURPOSE

This memorandum, for the METSAT (Meteorological Satellites) AMSU-A1 (Advanced Microwave Sounding Unit-A1) Project, reports the disturbance torque measurements of the A1 module with assembly serial number 108 (Aerojet part number 1331720-2). The measurements were performed in order to document the disturbance torque and momentum of the instrument.

SUMMARY

The disturbance torque and angular momentum profiles of the METSAT AMSU-A1 module, with assembly serial number 108, were measured on February 29, 2000 at the GenCorp Aerojet Azusa environmental testing facility. The measurements were taken in accordance with Aerojet Process Specification AE-26151/12 and Facility Test Procedure OC-462.

The peak, unfiltered disturbance torque of the AMSU-A1 S/N 108 module was measured to be 130.4, 60.1, and 108.6 lb-in (pound-inches) about the instrument X, Y, and Z coordinate axes, respectively. The METSAT AMSU-A1 instrument coordinate axes are shown in the Thermal Interface Control and Interface Configuration Drawing, with Aerojet drawing number 1333964. The peak disturbance torque magnitude, which is the vector sum of the torque in the individual axes, was measured to be 148.0 lb-in. The measurements show that the maximum disturbance torque components, in the unfiltered data, occur about the cross axes (X and Z) to the rotation axes of the reflectors. It is suspected that resonance of the force plate and crosstalk are causing large, high-frequency torque disturbances about the instrument's X and Z-axes.

The peak angular momentum of the AMSU-A1 S/N 108 module was derived to be 0.110, 0.620, and 0.0817 lb-in-sec (pound-inch-seconds) about the instrument X, Y, and Z coordinate axes, respectively. The peak angular momentum magnitude, which is the vector sum of the angular momenta in the individual axes, was derived to be 0.621 lb-in-sec.

The Fourier Transform of the disturbance torque exhibits peak spectral energies at frequencies of 5 Hz (Hertz), harmonics of 5 Hz, and 180 Hz. The peaks at 5 Hz and the harmonics correspond to the frequency of the earth viewing scans; the reflectors sweep through five beam positions in one second. The peak spectral energy at 180 Hz is suspected to be resonance of the test setup at the natural frequency of the force plate with the additional weight of the adapter plate and AMSU-A1 module.

BACKGROUND

A Kistler Force Plate dynamometer was used to measure the disturbance torque of the AMSU-A instrument, as shown in Figures 1 and 2. The two identical, synchronized reflectors of the AMSU-A1 instrument sweep through thirty earth-viewing beam positions, and cold/warm calibration positions. Five earth-viewing scenes are scanned in one second; the period of each scene is 0.2 second. The intermittent rotation of the AMSU-A1 reflectors, during scanning and calibration, imparts a disturbance torque to the module and spacecraft that they are installed on. The disturbance torque,

about an axis parallel to the reflector rotation axis, is proportional to the rotational moment of inertia and slew rate (angular acceleration) of the reflector. Products of inertia, or dynamic imbalances, of the reflector cause torque disturbances in the axes normal to the rotation axis. The disturbance torque test is performed in order characterize the disturbance torque and angular momentum of the AMSU-A1 instrument, and demonstrate compliance with the instrument requirements.

Analytical equations will be used to show the functional relationship between the disturbance torque, momentum, moments of inertia, angular velocity, and angular acceleration of the reflector. The torque, or sum of the moments about an origin, can be expressed as a function of the angular momentum by the conservation of angular momentum equation,

$$\vec{T}_o = \sum \vec{M}_o = \frac{d\vec{H}_{oR}}{dt} + \vec{\Omega}_R \times \vec{H}_o$$

The application of torque T to the reflector, by the DC torque motor, changes the angular momentum H of the reflector. The angular momentum H of the reflector, for rotation of the reflector about the fixed Y-axis, is defined by the following,

$$H_X = -I_{XY}\omega$$
$$H_Y = I_{YY}\omega$$
$$H_Z = -I_{ZY}\omega$$

where the angular velocity of the reflector Ω is ωj (j is a unit vector in the Y-axis) and I_{YY} is the rotational moment of inertia of the reflector. I_{XY} and I_{ZY} are the reflector's products of inertia terms which arise from asymmetry of the reflector about the XZ-plane. Substitution of the angular momentum, H, in the conservation of angular momentum equation yields expressions for the torque T:

$$T_X = -I_{XY}\alpha - I_{ZY}\omega^2$$
$$T_Y = I_{YY}\alpha$$
$$T_Z = -I_{ZY}\alpha + I_{XY}\omega^2$$

The angular acceleration of the reflector is α. Because angular momentum cannot be directly measured with the test setup, the integration of the torque profile over time is performed to derive the angular momentum about the reflector rotation axis,

$$H_Y(t) = \int_0^t T_Y(\tau) \cdot d\tau$$

The disturbance torque and angular momentum of the instrument, as measured by the force plate, are opposite (in sign) to the torque and angular momentum of the reflector. The torque of the instrument is a reaction (according to Newton's Third Law) to the torque that is applied to the reflector by the DC

motor. The disturbance torque $T_{instrument}$ and angular momentum $H_{instrument}$ of the instrument, as measured by the force plate, are related to the torque $T_{reflector}$ and angular momentum $H_{reflector}$ of the reflector:

$$T_{X,instrument} = -T_{X,reflector} = I_{XY}\alpha + I_{ZY}\omega^2$$

$$T_{Y,instrument} = -T_{Y,reflector} = -I_{YY}\alpha$$

$$T_{Z,instrument} = -T_{Z,reflector} = I_{ZY}\alpha - I_{XY}\omega^2$$

$$H_{X,instrument} = -H_{X,reflector} = I_{XY}\omega$$

$$H_{Y,instrument} = -H_{Y,reflector} = -I_{YY}\omega$$

$$H_{Z,instrument} = -H_{Z,reflector} = I_{ZY}\omega$$

Predicted disturbance torque and momentum profiles of the reflector and instrument are shown in Figure 3. A "cartoon" response of the reflector motor to step commands is shown in Figure 3. The reflector beam position, as a function of time, is plotted for the reflector response to two consecutive step commands (to earth-viewing scene scenes). The reflector performs a slew from the previous reflector position to the first scene, then dwells for viewing. This sequence is repeated for the second scene. The angular momentum of the reflector, which is proportional to the time-derivative of the reflector beam position, is plotted in Figure 3. The torque of the reflector, which is proportional to the time-derivative of the angular momentum, is also plotted in Figure 3. The disturbance torque pattern for each reflector slew shows a torque impulse followed by a restoring torque impulse. The disturbance torque and angular momentum of the instrument (profiles on the right side in Figure 3) are opposite (in sign) to the torque and momentum of the reflector (profiles on the left side in Figure 3).

DISCUSSION OF RESULTS

A block diagram of the test equipment setup is shown in Figure 4. The test setup utilizes a Kistler 9253A force plate to measure force and moment in three orthogonal axes, a 5017A charge amplifier to convert the charges from the piezoelectric force plate transducers to voltages, and a Tekronix TestLab 2520 data acquisition system for data collection. Analog data is stored on a Metrum RSR 512 tape recorder for data archival. The Kistler 9253A force plate utilizes four piezoelectric force transducers. Each of the four force transducers measures three components of force. The outputs from the four transducers are combined to give six DOFs (degrees of freedom): three components of the net applied force, and three components of the net applied moment as shown in Figure 5. The force plate cannot resolve whether only an applied torque causes a measured moment, or a combination of torque and offset force from the center of the plate causes that moment. Because the center of gravity of the reflector is aligned with the rotation axis, it is expected that residual (and possibly offset) forces should not arise from the rotation of the reflector. It will be assumed in the analysis that the moments measured by the force plate are due only to torque disturbances from the reflectors, and not to offset forces. Any residual forces measured by the force plate may be due to resonance and vibration of the test setup, and crosstalk. Therefore the terms "torque" and "moment" will be used interchangeably in this report. All measurements were acquired with a sampling frequency of 2000 Hz in order to achieve

a 1000 Hz Nyquist frequency, or 1000 Hz frequency bandwidth in the spectral analysis (Fourier Transforms). An illustration of the AMSU-A1 module mounted on the force plate is shown in Figure 2. The instrument's coordinate axes X_{A1}, Y_{A1}, and Z_{A1} are parallel to the force plate's coordinate axes X, Y, and Z, respectively.

The usable frequency range of the force plate is limited by drift of the charge amplifiers at DC (direct current), and resonance at the natural frequency of the force plate with the additional mass of the AMSU-A1 module and adapter plate at the upper frequency limit. The lower frequency, or drift of the charge amplifiers, is influenced by temperature changes; temperature changes cause drift of the zero levels. The lower limit of frequency range of the system is also determined by the quality of the electrical insulation; the RC (Resistor-Capacitor circuit) time constant for DC measurements is dependent on the open circuit resistance (quality of the insulation between signal line and connecting ground). Amplification of the applied forces and torque, at the natural frequency of the force plate system, influences the upper frequency limit of the measurements. Addition of mass to the force plate has the effect of reducing the natural frequency of the force plate. The natural frequency of the force plate itself without additional mass is approximately 800 Hz in all three axes. The natural frequency of the AMSU-A disturbance torque setup could be determined by performing a frequency analysis of data obtained from tapping the force plate with an instrumented impulse hammer (tap test).

The calibration of the test setup was validated by measuring known forces and moments applied to the force plate. Static forces and moments were applied to the force plate by placing 4 and 10 pound masses at different locations, offset from the center of the force plate. The results of the calibration checks are plotted in Figure 6. The measured moment versus applied moment, about the force plate X and Y-axes, are shown in Figure 6 above and below, respectively. Error bars of ±10%, in the expected measured moments, are shown in the two plots. The measurements demonstrate that applied moments about the X and Y-axes can be measured to within 10% of the expected values over a –62 to 62 lb-in range. A torque about the plate Z-axis was applied to the force plate by tightening a screw on top of the force plate to 360 lb-in with a torque wrench. The torque was measured by the force plate to be 342.2 lb-in; this is within 5% of the applied torque (360 lb-in).

Table I presents a summary of RMS (Root-Mean-Square) measured disturbance torque over 10 seconds obtained from the AMSU-A1 S/N 108 instrument. RMS values of the background noise, in which the instrument is not operating, are also shown. The RMS disturbance torque of the AMSU-A1 S/N 108 module was measured to be 20.7, 10.7, and 17.2 lb-in about the instrument X_{A1}, Y_{A1}, and Z_{A1} axes, respectively. The RMS torque for background noise was measured to be 0.624, 0.493, and 0.183 lb-in about the instrument X_{A1}, Y_{A1}, and Z_{A1} axes, respectively. The signal to noise ratio was calculated for each torque component; these are also shown in Table I. The signal to noise ratios, which varied between 26.7 and 39.5 dB, were adequate for measurements with good resolution.

Table II presents a summary of the peak unfiltered and low-pass filtered (100 and 10 Hz cut-off frequencies) disturbance torque data. An IIR (Infinite Impulse Response) Butterworth filter was utilized to perform low-pass filtering of the data. The data was filtered with a cut-off frequency of 10 Hz, for AOCS (Attitude Orbital Control System, from DC to 10 Hz) issues, and 100 Hz, for microdynamics (from DC to 100 Hz) issues. The unfiltered torque profiles are not fully useful because

they contain high frequency components arising from vibration and resonance of the force plate and instrument (frequencies higher than 100 Hz). The disturbance torque profiles should be independent of the test setup. However, using disturbance torque values from the unfiltered data, which contain the higher frequency components, may be conservative because they are generally larger than the values from the low-pass filtered data. Plots of the peak unfiltered, 10 Hz low-pass filtered, and 100 Hz low-pass filtered disturbance torque profiles are shown in Figures 12, 13, and 14, respectively.

Tables III, IV, and V provide a compilation of peak disturbance torque and angular momentum values from previously tested AMSU-A1 instruments, and the S/N 108 instrument discussed herein. The disturbance torque and angular momentum peak values of the S/N 108 instrument are slightly higher than those of the S/N 105-107 instruments, but nearly matches those of the S/N 109 instrument.

Profiles of the measured disturbance torque and derived angular momentum, during full operation of the METSAT AMSU-A1 S/N 108, are shown in Figures 8 through 10. The RSS (Root-Sum-Squares) disturbance torque magnitude, which is the magnitude of the vector sum of the components in each axis, is plotted in Figure 7. Fourier-Transforms of the disturbance torque data are shown in Figure 11. An artificial linear trend could be introduced in the angular momentum data due to the time-integration of a small DC offset in the disturbance torque data. Therefore the disturbance torque profiles presented in this report have been detrended in order to derive valid angular momentum magnitudes. Unfiltered, 100 Hz low-pass filtered, and 10 Hz low-pass filtered torque profiles about all three axes are shown in Figures 12, 13, and 14, respectively.

Figure 7 (above) is a plot of the disturbance torque magnitude, which is the square root of the sum of the squares of the torque components about the instrument X, Y, and Z-axes. The angular momentum profile is also plotted in Figure 7 (below). The large peaks in the angular momentum profile (Figure 7, below) correspond to the reflectors' slew to warm/cold calibration positions. The smaller peaks correspond to the reflectors' earth-viewing scans. The maximum exhibited disturbance torque and angular momentum magnitudes are 148.0 lb-in and 0.621 lb-in-sec, respectively.

The disturbance torque profiles are plotted in Figures 8 through 10 (above) for the individual instrument axes. Refer to Figure 2 for the definition of the instrument axes X_{A1}, Y_{A1}, and Z_{A1}. The peak disturbance torque components are 130.4, 60.1, and 108.6 lb-in about the instrument X, Y, and Z coordinate axes, respectively. The measurements show that the maximum disturbance torque peaks, of the unfiltered data, occur about the axes normal to the rotation axes of the reflectors. It is suspected that resonance of the force plate, vibration of the instrument, and crosstalk are causing these large, high-frequency torque disturbances about the cross axes. It is noted that these large magnitude torque disturbances in the cross axes are of short duration (high frequency) and do not contribute significantly to the angular momentum. The angular momentum profiles are plotted for the individual instrument axes in Figures 8 through 10 (below). The peak angular momentum of the A1 S/N 108 module are 0.110, 0.620, and 0.0817 lb-in-sec about the instrument X, Y, and Z coordinate axes, respectively.
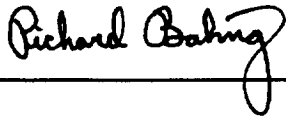
Fourier Transforms of the disturbance torque data were obtained. The Fourier Transform of the disturbance torque exhibits peak spectral energies at frequencies of 5 Hz (Hertz), harmonics of 5 Hz, and 180 Hz. The peaks at 5 Hz and the harmonics correspond to the frequency of the earth viewing scans; the reflectors sweep through five beam positions in one second. The peak spectral energy at 180

Hz is suspected to be resonance of the test setup at the natural frequency of the force plate with the additional weight of the adapter plate, approximately 60 pounds, and AMSU-A1 module, approximately 120 pounds. The natural frequencies of the 88-pound force plate, without any additional mounted hardware, are 800, 750, 850 Hz in the plate X, Y, and Z-axes, respectively.

The disturbance torque profile of the low-pass filtered data, in the middle of Figure 14, and angular momentum profile, in the bottom of Figure 8, agree very well with the predicted profiles in the "cartoons" in Figure 3 (right side, instrument).

CONCLUSIONS AND RECOMMENDATIONS

The disturbance torque and angular momentum of the AMSU-A1 S/N 108 module, in full operation, were measured and reported in this memorandum. The test setup was shown to measure static moments within ±10% of the applied moments. It would be useful in future tests to demonstrate the dynamic response and calibration of the force plate setup. The frequency response of the force plate, based on the manufacturer's specifications, is assumed to be adequate for the AMSU-A1 disturbance torque measurements. All aspects of the AMSU-A1 S/N 108 disturbance torque and momentum test were satisfactory.

Richard Bahng, Applied Mechanics and Structures

Table I. RMS (Root-Mean-Square) and Peak Torque of METSAT AMSU-A1 S/N 108 over 10 Seconds of Acquisition.

	Nadir Axis (X_{A1})	Velocity Axis (*Y_{A1})	Sun Axis (Z_{A1})
RMS Torque (lb-in)	20.7	10.7	17.2
Peak Torque (lb-in)	130.4	60.1	108.6
Peak Angular Momentum (lb-in-s)	0.110	0.620	0.0817
RMS Torque of Noise (lb-in)	0.624	0.493	0.183
Signal to Noise Ratio (dB)	30.4	26.7	39.5

*Axis Parallel to Reflector/Drive Motor Shaft.

Root-Mean-Square Torque over 10 seconds: $T_{RMS} = \left[\dfrac{1}{10\sec} \int_0^{10\sec} T^2(t) \cdot dt \right]^{1/2}$

Signal to Noise Ratio (decibels, dB): $S/N = 20 \cdot \log \dfrac{T_{unit,RMS}}{T_{noise,RMS}}$

Table II. Summary of Unfiltered, 100 Hz Low-Pass Filtered, and 10 Hz Low-Pass Filtered Peak Torques.

AMSU-A1 S/N 108	Unfiltered	100 Hz Low-Pass Filtered	10 Hz Low-Pass Filtered
T_{XA1} (lb-in)	130.4	13.7	0.801
T_{YA1} (lb-in)	60.1	40.3	14.8
T_{ZA1} (lb-in)	108.6	9.50	0.636

Table III. Peak disturbance torque and angular momentum values *(Unfiltered)*

T=Torque H=Angular Momentum	AMSU-A1 S/N 105	AMSU-A1 S/N 106	AMSU-A1 S/N 107	AMSU-A1 S/N 108	AMSU-A1 S/N 109
T_{XA2} **nadir (lb-in)**	114	65	84.2	130.4	169
T_{YA2} **velocity (lb-in)** **(rotation axis)**	55	45	46.1	60.1	59.1
T_{ZA2} **sun(lb-in)**	90	98	114.7	108.6	91.4
H_{XA2} **nadir (lb-in-s)**	0.12	0.1	0.08	0.110	0.149
H_{YA2} **velocity (lb-in-s)** **(rotation axis)**	0.5	0.5	0.57	0.620	0.622
H_{ZA2} **sun (lb-in-s)**	0.08	0.1	0.10	0.0817	0.0912

Table IV. Peak disturbance torque and angular momentum values *(DC to 100 Hz)*

T=Torque H=Angular Momentum	AMSU-A1 S/N 105	AMSU-A1 S/N 106	AMSU-A1 S/N 107	AMSU-A1 S/N 108	AMSU-A1 S/N 109
T_{XA2} **nadir (lb-in)**	12.96	10.23	12.38	13.7	19.9
T_{YA2} **velocity (lb-in)** **(rotation axis)**	33.58	36.62	36.64	40.3	35.4
T_{ZA2} **sun(lb-in)**	6.76	14.39	9.86	9.50	10.9
H_{XA2} **nadir (lb-in-s)**	0.0417	0.0789	0.0387	0.0318	0.0482
H_{YA2} **velocity (lb-in-s)** **(rotation axis)**	0.552	0.563	0.565	0.614	0.618
H_{ZA2} **sun (lb-in-s)**	0.0365	0.0490	0.0306	0.0308	0.0447

Table V. Peak disturbance torque and angular momentum values *(DC to 10 Hz)*

T=Torque H=Angular Momentum	AMSU-A1 S/N 105	AMSU-A1 S/N 106	AMSU-A1 S/N 107	AMSU-A1 S/N 108	AMSU-A1 S/N 109
T_{XA2} **nadir (lb-in)**	0.406	0.697	0.433	0.801	0.689
T_{YA2} **velocity (lb-in)** **(rotation axis)**	13.86	14.07	13.80	14.8	14.7
T_{ZA2} **sun(lb-in)**	0.385	0.514	0.548	0.636	0.395
H_{XA2} **nadir (lb-in-s)**	0.0266	0.0712	0.0250	0.0283	0.0314
H_{YA2} **velocity (lb-in-s)** **(rotation axis)**	0.547	0.561	0.555	0.601	0.614
H_{ZA2} **sun (lb-in-s)**	0.0343	0.0438	0.0282	0.0273	0.0381

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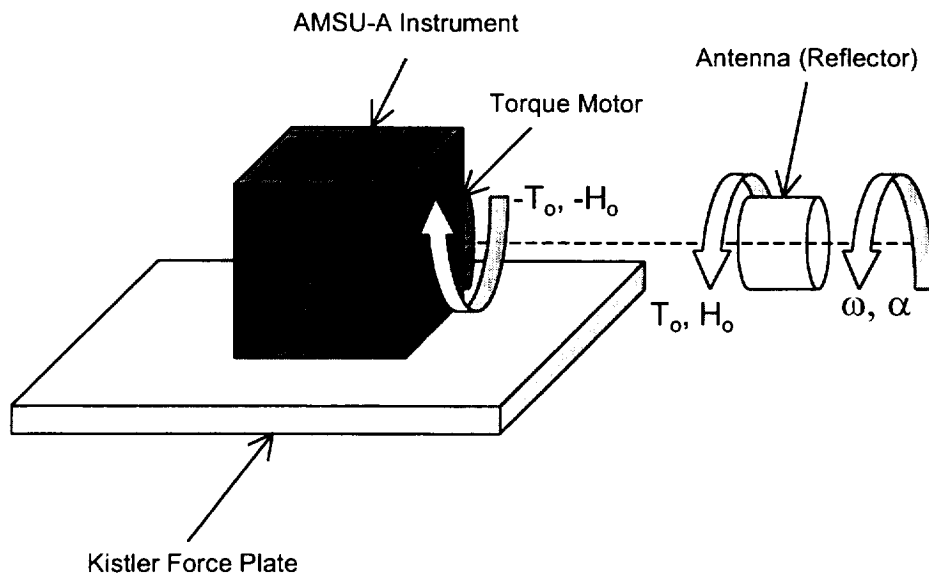|					

Figure 1. The disturbance torque of the instrument, as measured by the force plate, is the reaction due to the torque applied to the reflector.
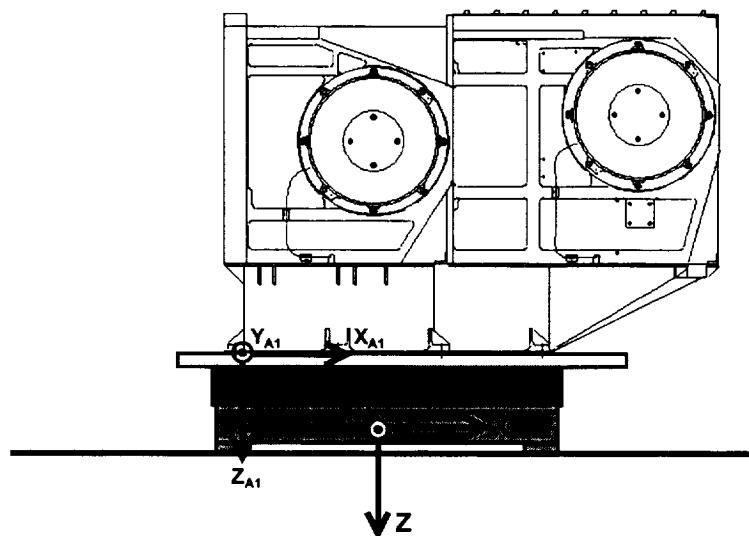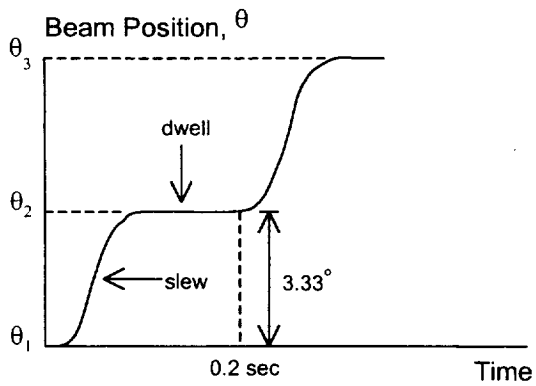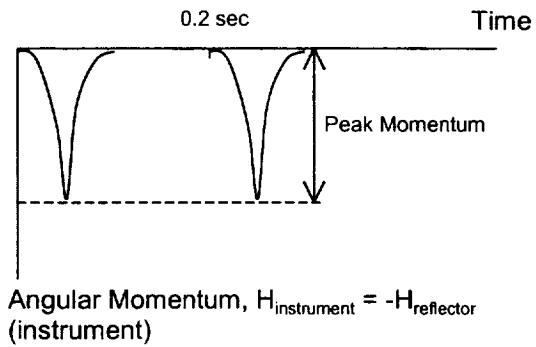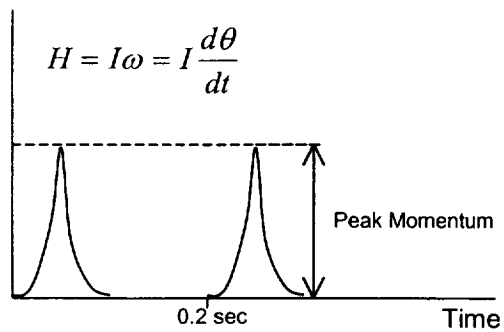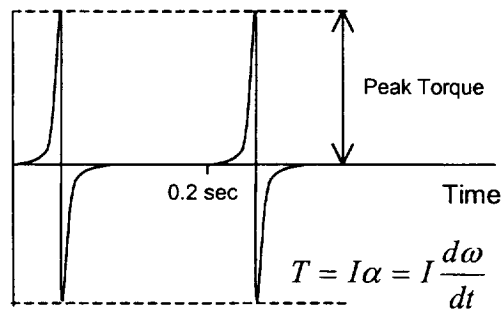

Figure 2. The coordinate axes X_{A1}, Y_{A1}, and Z_{A1} of the AMSU-A1 instrument are parallel to the Kistler Force Plate coordinate axes, X, Y, and Z, respectively.

Beam Position, θ

θ_3

dwell

θ_2

slew

$3.33°$

θ_1

0.2 sec

Time

Angular Momentum, $H_{reflector}$ (Reflector)

$$H = I\omega = I\frac{d\theta}{dt}$$

Peak Momentum

0.2 sec

Time

0.2 sec   Time

Peak Momentum

Angular Momentum, $H_{instrument} = -H_{reflector}$
(instrument)

Torque, $T_{reflector}$ (Reflector)

Peak Torque

0.2 sec

Time

$$T = I\alpha = I\frac{d\omega}{dt}$$

Torque, $T_{instrument} = -T_{reflector}$
(instrument, as measured by force plate)

Peak Torque

0.2 sec

Time
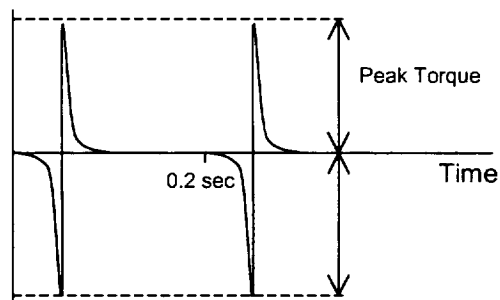
Figure 3. Reflector Beam Position, Momentum, and Torque for a Sweep Through Two Scenes.
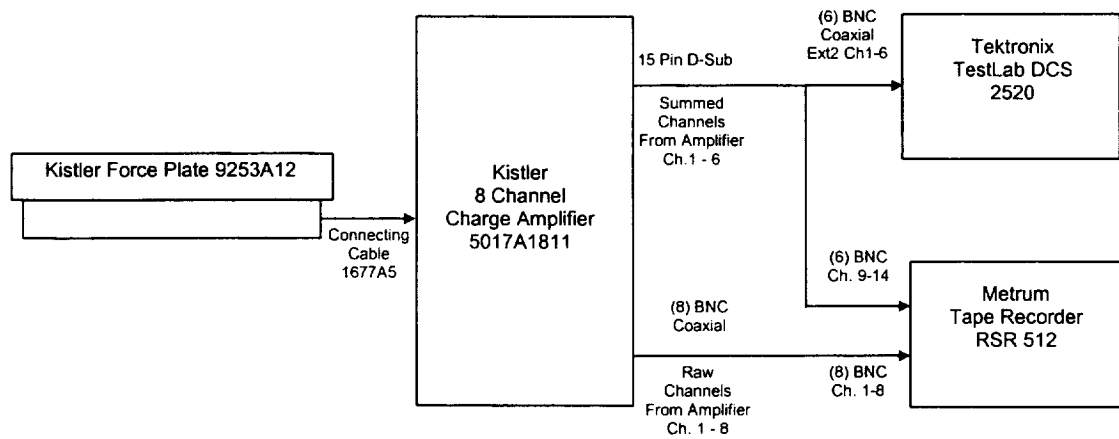
Figure 4. Block Diagram of the Disturbance Torque Test Setup
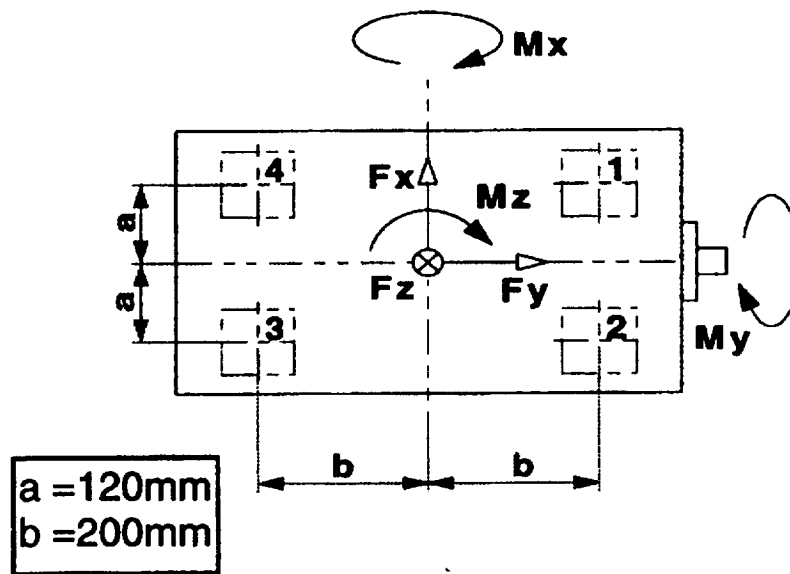

a =120mm
b =200mm

Figure 5. The Kistler Force Plate assembles the forces measured at the four transducers (at 1, 2, 3, and 4) and outputs the net applied force and moment.
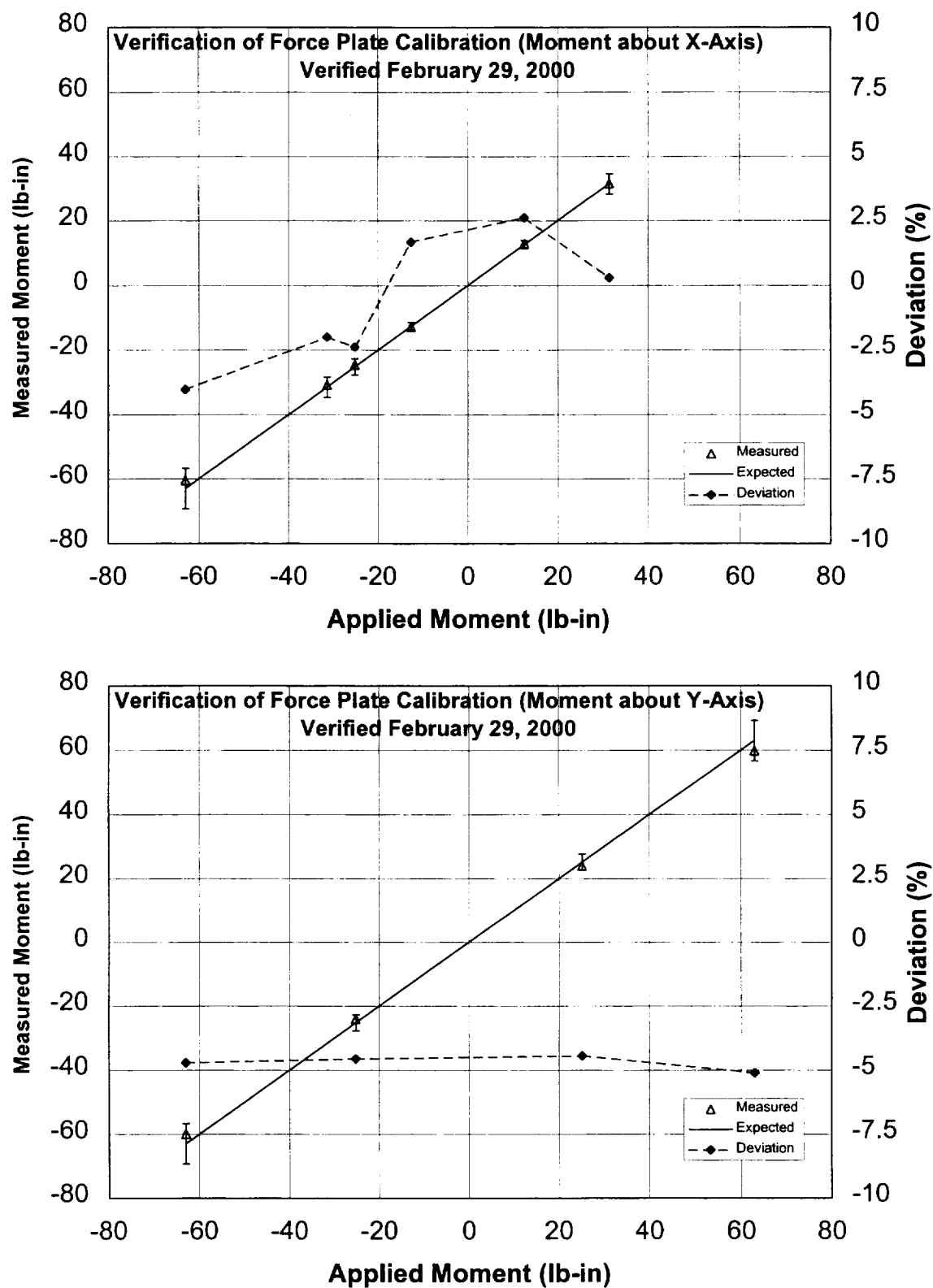
Figure 6. Verification of Kistler Force Plate/Charge Amplifiers Calibration.
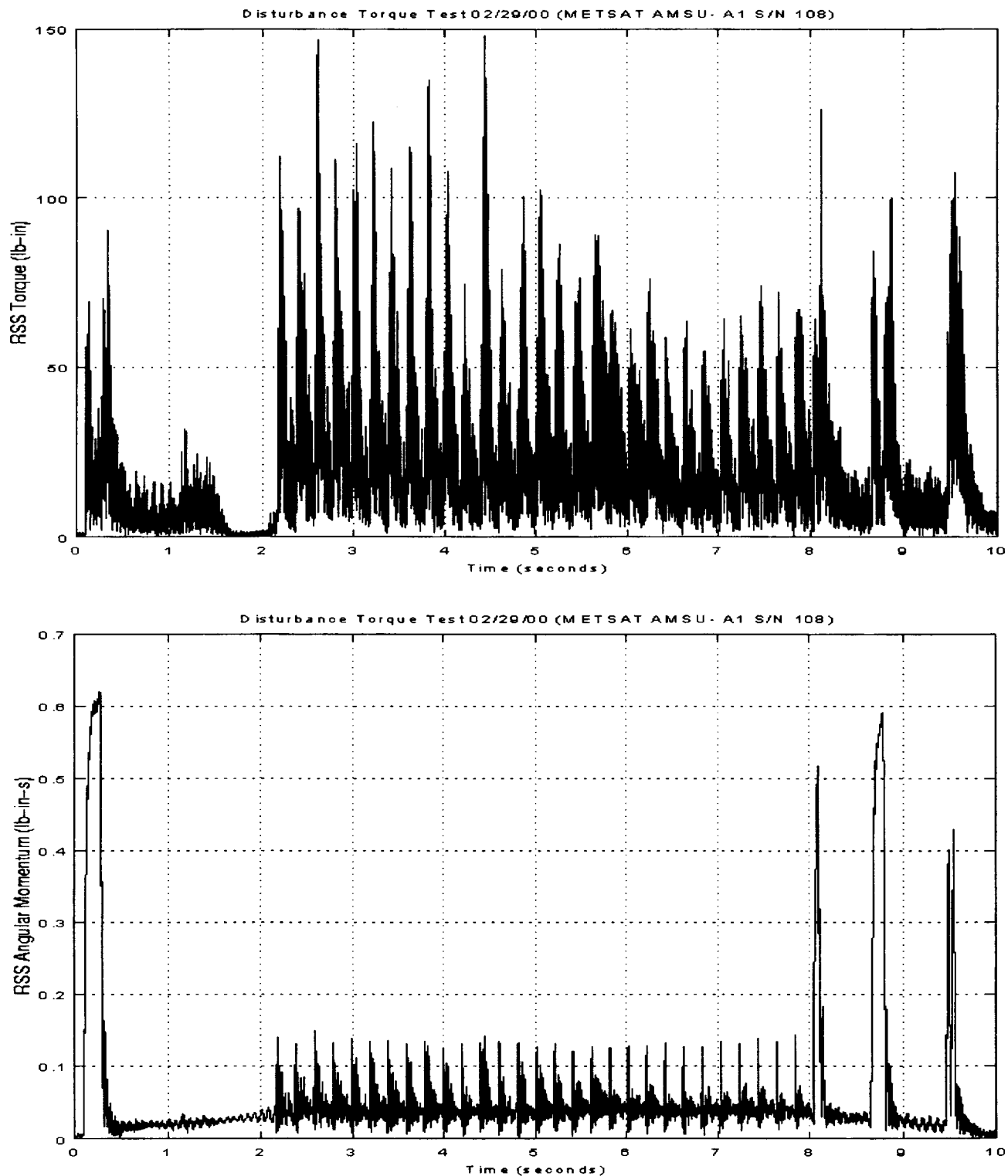
Figure 7. AMSU-A1 S/N 108 RSS (Root-Sum-Squares) Disturbance Torque (above), and Angular Momentum (below).
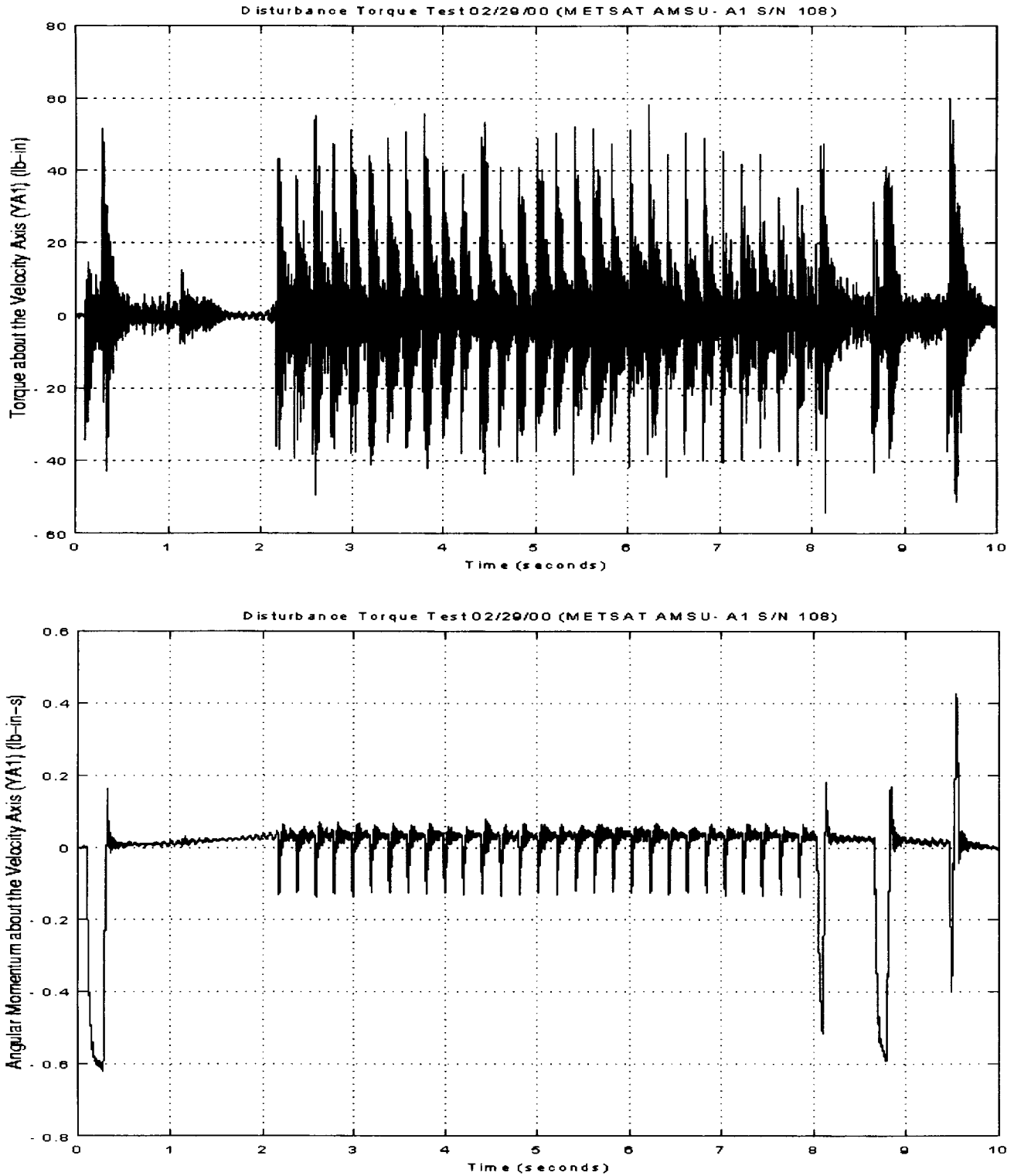
Figure 8. AMSU-A1 S/N 108 Disturbance Torque (above) and Momentum (below) about the Velocity Axis.
Note: The rotation axes of the AMSU-A1 reflectors are parallel to the velocity axis.
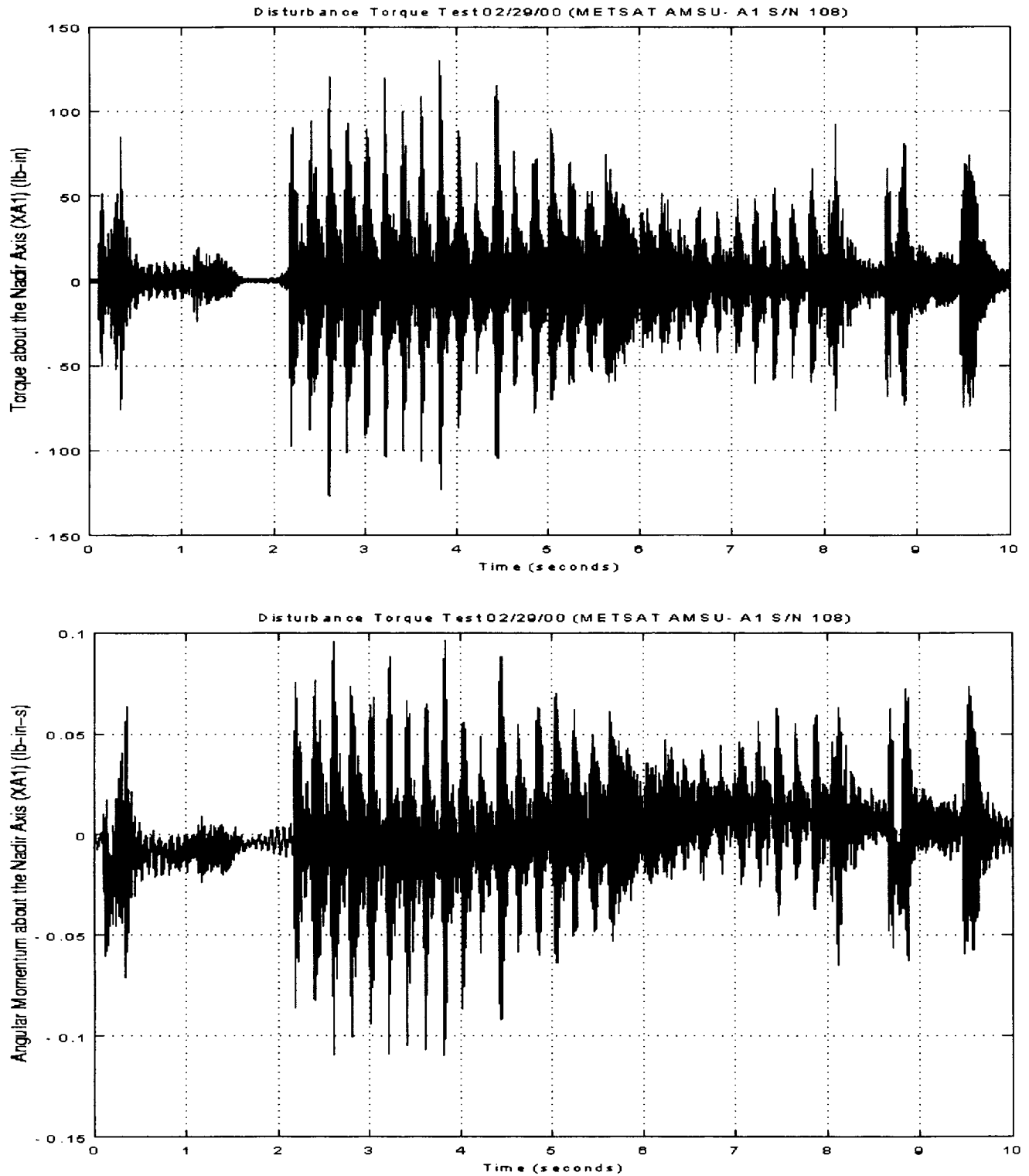
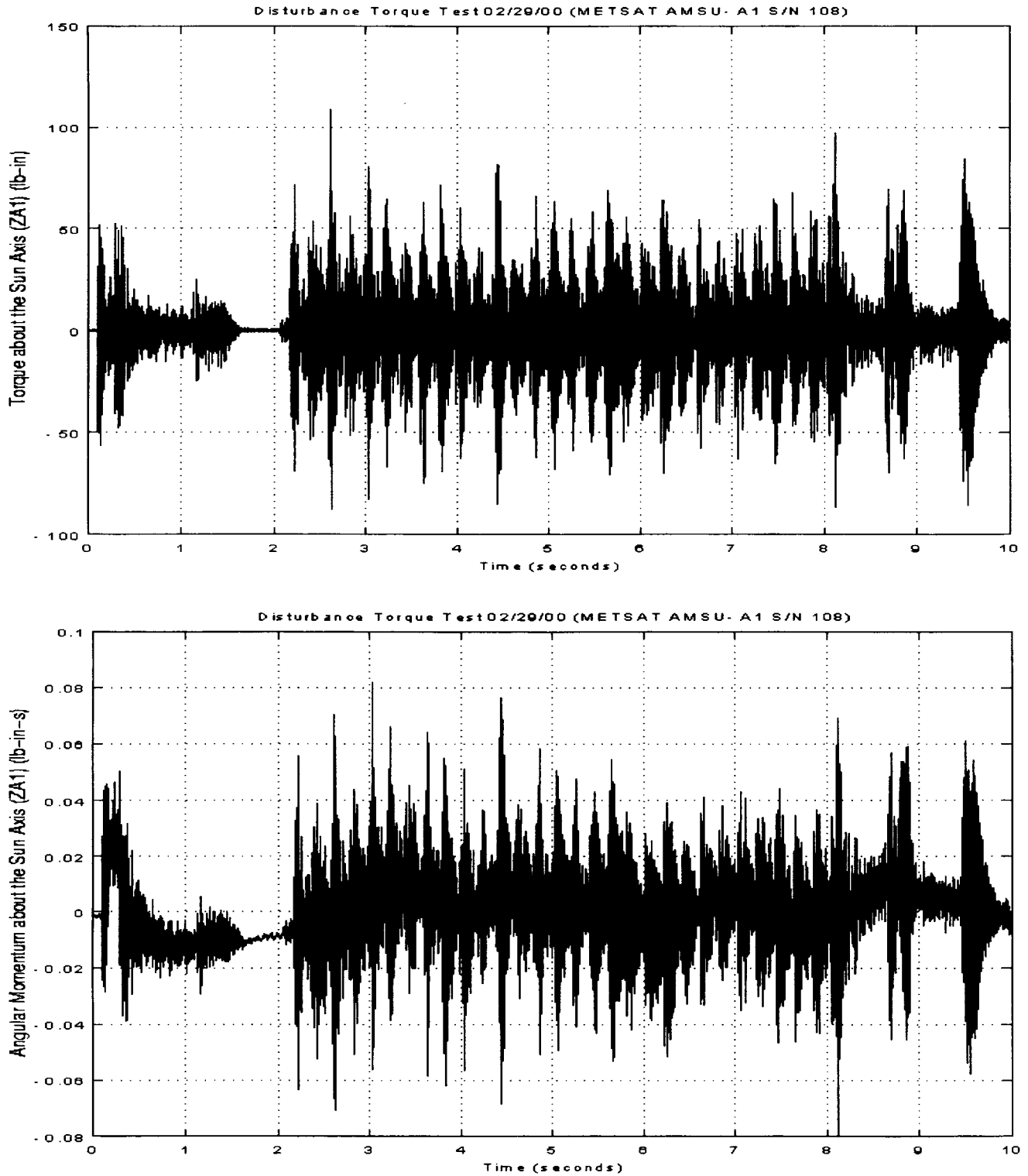**Figure 9.** AMSU-A1 S/N 108 Disturbance Torque (above) and Momentum (below) about the Nadir Axis.

Figure 10. AMSU-A1 S/N 108 Disturbance Torque (above) and Momentum (below) about the Sun Axis.
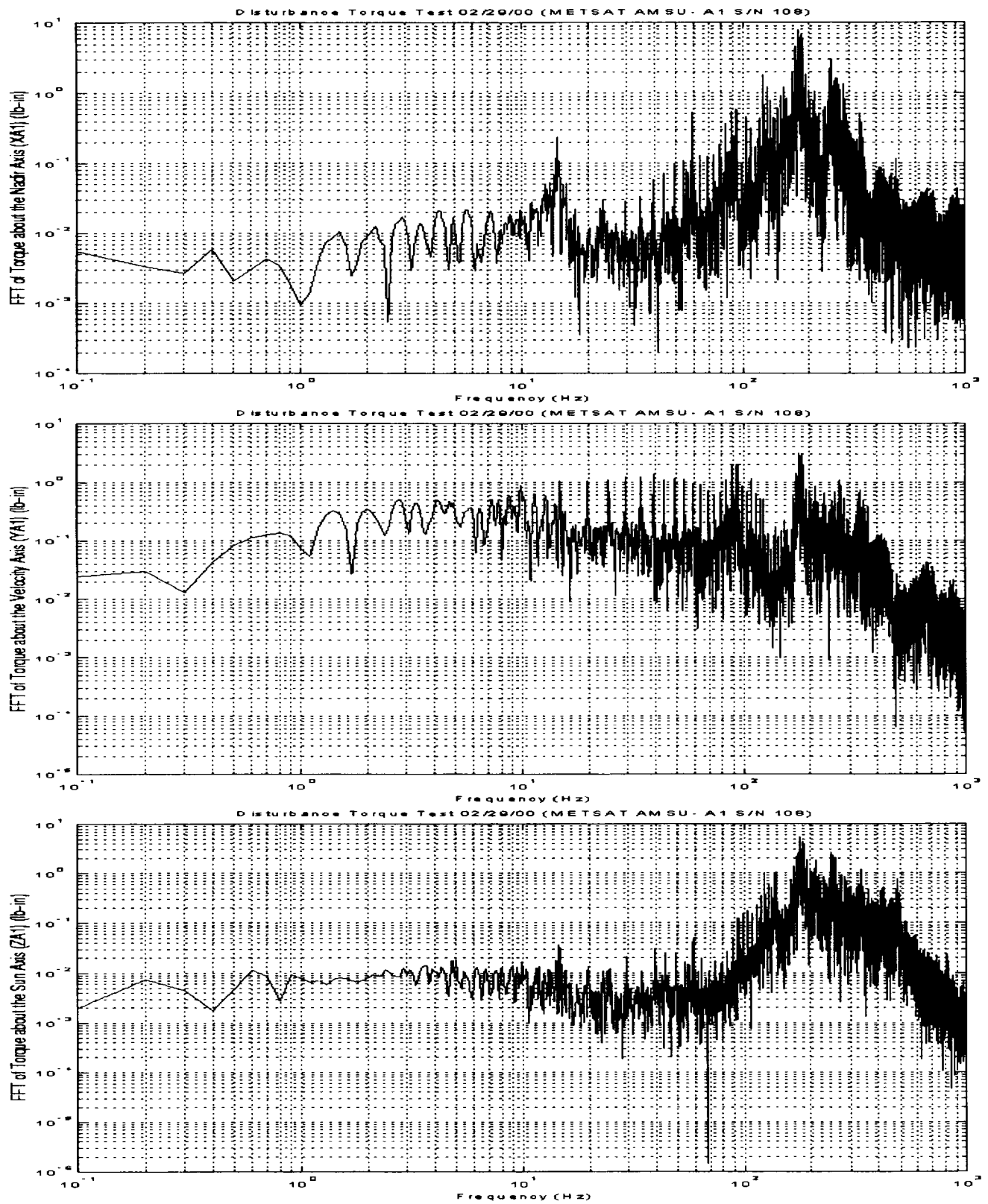
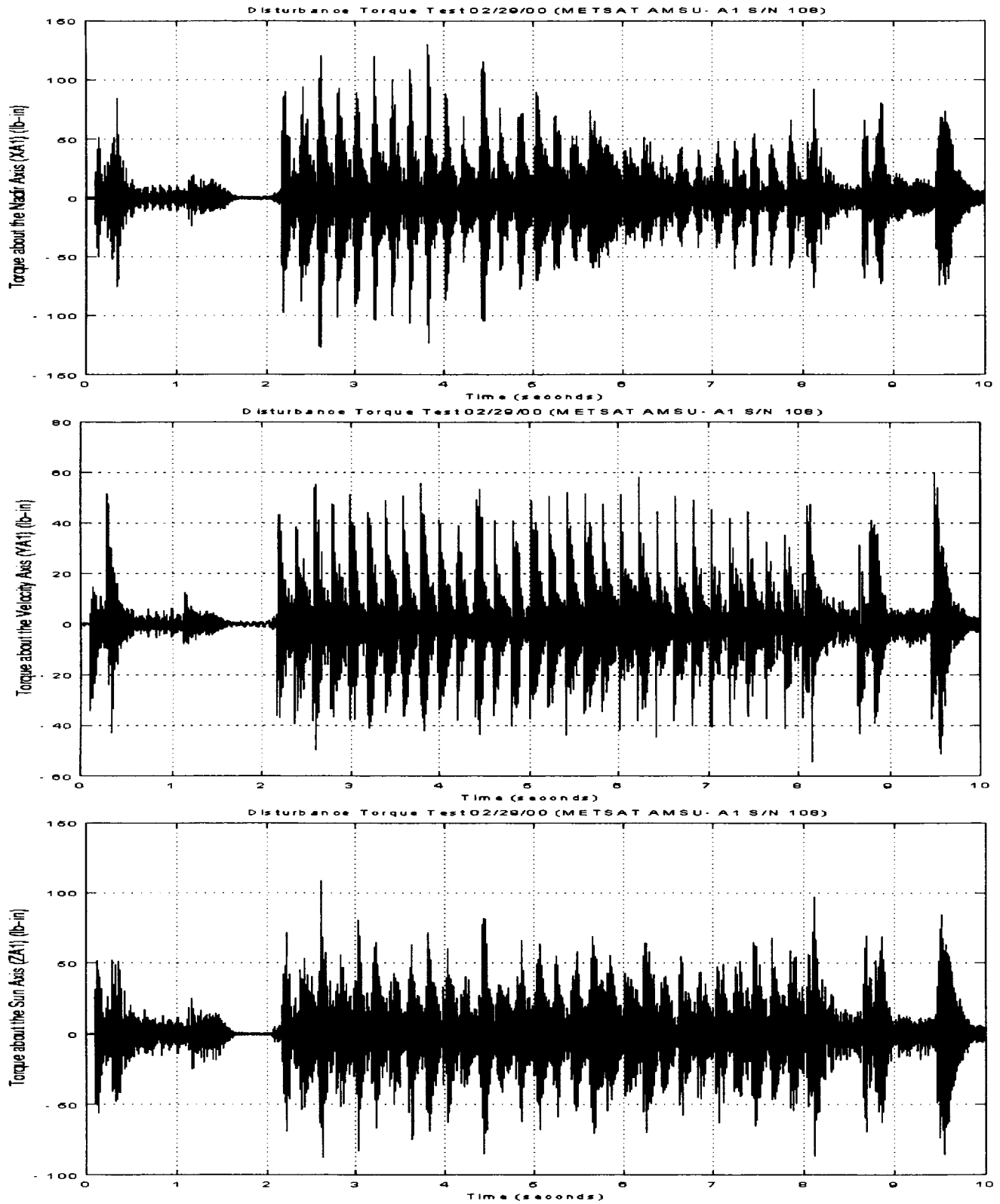**Figure 11.** Fourier Transforms of Disturbance Torque in the Nadir, Velocity, and Sun Axes.

Figure 12. Disturbance torque (unfiltered) of the AMSU-A1 S/N 108 unit.
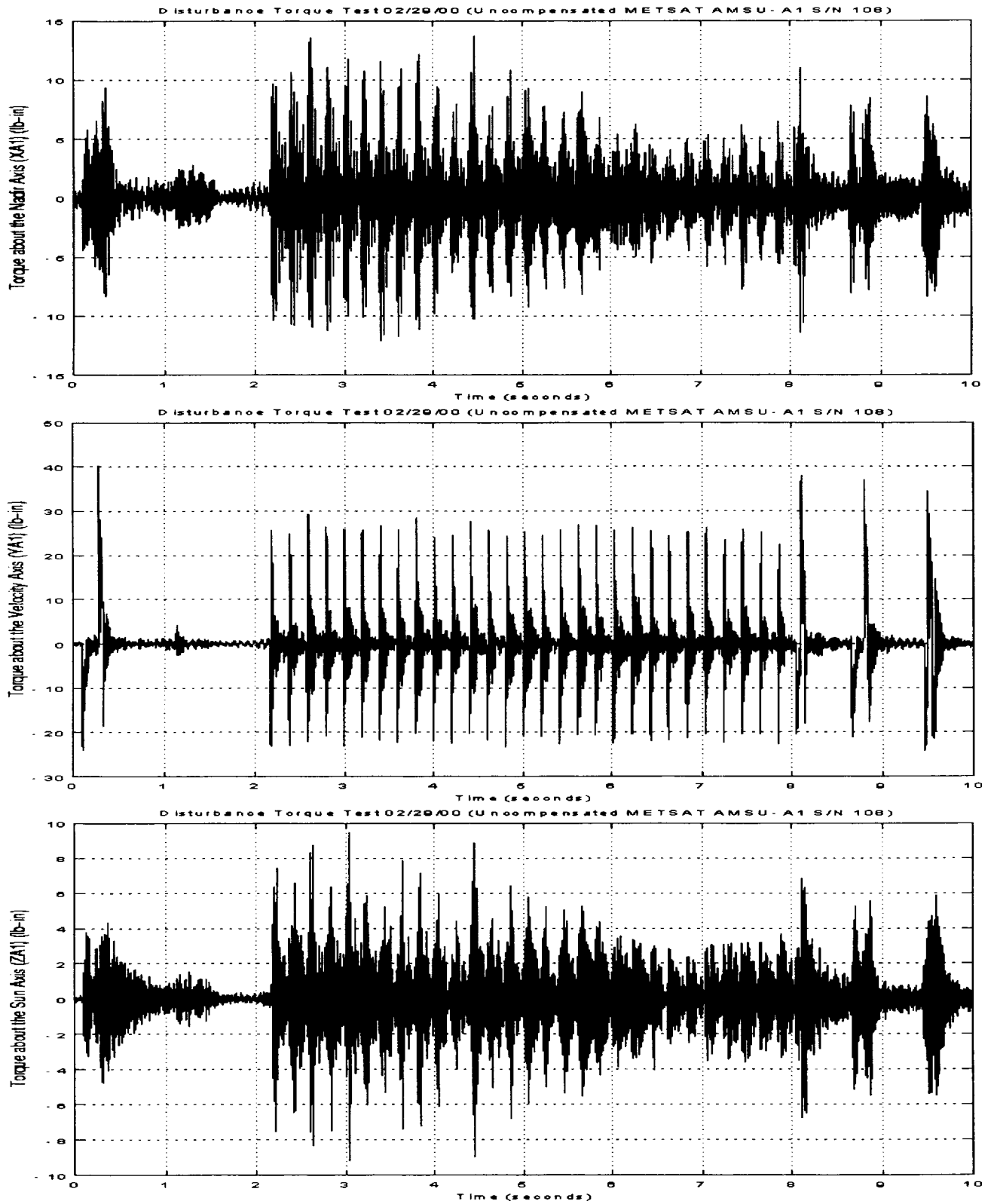
Figure 13. Disturbance torque (100 Hz low-pass filtered) of the AMSU-A1 S/N 108 unit.
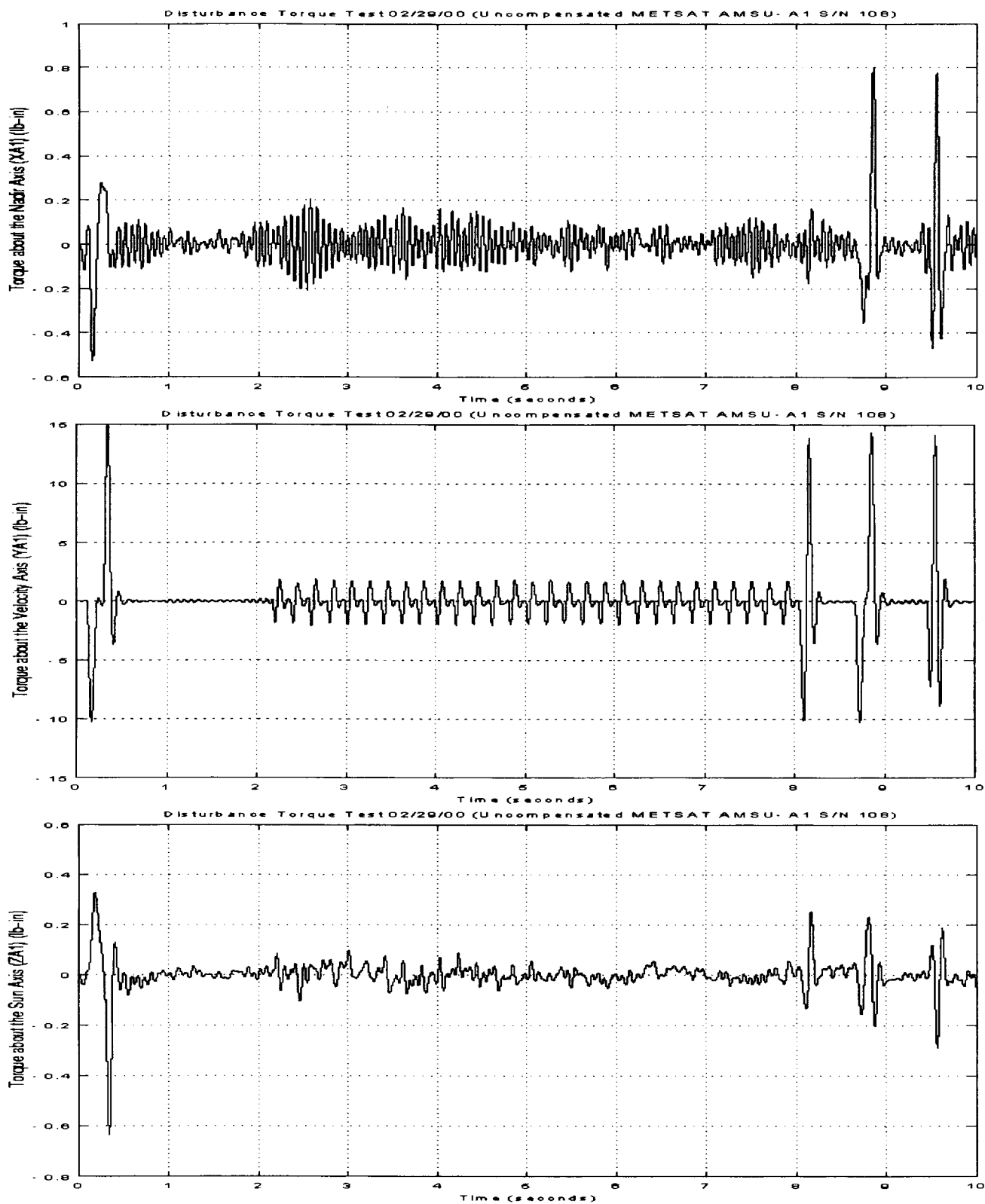
Figure 14. Disturbance torque (10 Hz low-pass filtered) of the AMSU-A1 S/N 108 unit.

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Report Documentation Page

1. Report No. ---	2. Government Accession No. ---	3. Recipient's Catalog No. ---

4. Title and Subtitle Integrated Advanced Microwave Sounding Unit-A (AMSU-A), Engineering Test Report	5. Report Date **15 March 2000**
	6. Performing Organization Code ---

7. Author(s) **R. Bahng**	8. Performing Organization Report No. 11643
	10. Work Unit No. ---

9. Performing Organization Name and Address Aerojet 1100 W. Hollyvale Azusa, CA 91702	11. Contract or Grant No. NAS 5-32314
12. Sponsoring Agency Name and Address NASA Goddard Space Flight Center Greenbelt, Maryland 20771	13. Type of Report and Period Covered Final
	14. Sponsoring Agency Code ---

15. Supplementary Notes

---

16. ABSTRACT (*Maximum 200 words*)

This is the Engineering Test Report, AMSU-A1 S/N 108 Disturbance Torque and Angular Momentum Measurements, for the Integrated Advanced Microwave Sounding Unit-A (AMSU-A).

17. Key Words (Suggested by Author(s)) EOS Microwave System	18. Distribution Statement Unclassified --- Unlimited

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of pages	22. Price ---

NASA FORM 1626 OCT 86

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Integrated Advanced Microwave Sounding Unit-A (AMSU-A), Engineering Test Report	NAS 5-32314

6. AUTHOR(S)
R. Bahng

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
Aerojet 1100 W. Hollyvale Azusa, CA 91702	11643 15 March 2000

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA Goddard Space Flight Center Greenbelt, Maryland 20771	---

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13. ABSTRACT (*Maximum 200 words*)

This is the Engineering Test Report, AMSU-A1 S/N 108 Disturbance Torque and Angular Momentum Measurements, for the Integrated Advanced Microwave Sounding Unit-A (AMSU-A).

14. SUBJECT TERMS		15. NUMBER OF PAGES
EOS Microwave System		
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